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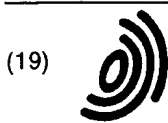
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(54) **Adjustable filter means**

Regelbarer Filter

Filtre réglable

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**EP-A- 0 453 213 DE-A- 3 721 918**  
**US-A- 4 907 293**

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## Description

The invention relates to an adjustable filter means which is responsive to the type of interference signal received. The adjustable filter means is particularly but not exclusively applicable to digital mobile phone systems.

The selectivity of the filter means in a cellular radio telephone is typically designed as a compromise regarding divergent filtering requirements. In digital phones filtering is performed by analog intermediate frequency filters and/or by baseband filters. The latter may also be realized in an SC-technique or with digital signal processing.

The most important divergent requirements when determining the appropriate filter requirements are attenuation of the adjacent channel, the required performance of the same channel, and sensitivity or the noise bandwidth. Signals comprising each of the above types of interference signal have different frequency responses. In individual cases the optimal filter response, on certain conditions, leads to a constant signal-to-noise distance over the whole signal band. Some optimum filter responses for different interference signals are presented below.

Figure 1 shows a situation, where a signal 1 is received at the sensitivity level. Then the interference signal is white Gaussian noise 3. In this case the optimum filter is a so called matched filter 2 having a frequency response equal to the signal response. Figure 2 shows a situation, where the signal 6 interfering with the received signal 4 consists of co-channel interference. In the case of digital networks this test is performed at a high signal level, whereby the importance of the noise is negligible. This also better corresponds to the actual situation in a network which is operated in the capacity limited region. The optimum filter 5 in this case has a flat frequency response in the signal band. Figure 3 shows a situation where the signal 9 interfering with the received signal 7 is interference from an adjacent channel. In this case the suitable optimum filter response 8 is asymmetric relative to the center frequency.

In prior selectivity filters it was necessary to select a compromise filter having a response of a particular type, regardless of the interference type turning out to be significant in practice. Thereby the receiver performance considerably depends on the nature of the interference. Particularly interference on the adjacent channel and a situation at the sensitivity level results to poor performance with a fixed compromise filter compared to that with an adaptive filter.

An alternative filtering method comprised carrying out a complete spectral analysis of the received signal and matching an adjustable filter to the interference signal portion of the received signal exactly, as disclosed in US-A-4882668 and EP-A-0 453 213. However, such a method requires considerable processor capacity.

In accordance with the present invention there is provided an adjustable filter means for selectively atten-

uating an interference signal, said interference signal being part of a received signal in a cellular radio telephone, the adjustable filter means comprising, means for analysing the received signal to determine the type of interference signal present therein from a predetermined set of interference signal types, means for generating a control signal indicative of one of said predetermined set of interference signal types so determined, and means for applying the received signal and the control signal to adaptive filtering means the frequency response of which is variable in response to said control signal to attenuate the interference signal.

An advantage of the present invention is to provide better filtering and receiver performance than in prior equipment, and/or to provide enhanced receiver performance with a reduction in processor capacity requirements.

An embodiment of the invention is described below, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram illustrating an input signal comprising a white Gaussian noise interference;

Figure 2 is a schematic diagram illustrating an input signal comprising a same channel interference signal (co-channel interference);

Figure 3 is a schematic diagram illustrating an input signal comprising an adjacent channel interference; and

Figure 4 illustrates a circuit diagram of an adjustable filter means in accordance with the present invention.

With reference to Figure 4 the received digital signal is supplied in a known way into two branches, the so called I, Q branches. In one branch the signal is mixed with the local oscillator frequency  $L_0$  and in the other branch with the frequency  $L_0$  90° having a 90 degrees phase shift relative to the frequency  $L_0$ .

The means for analysing the received signal 10 is realized by a spectrum analyzer, which identifies the type of interference signal present from a predetermined set of interference signal types illustrated in Figures 1 to 3. The I and Q signals are supplied to the filter 11, which is an adaptive filtering means which is responsive to the type of interference signal determined by the means for analysing the received signal 10. The means for analysing the received signal provides a control signal to the adaptive filter means 12 dependent on the type of interference signal detected and the adaptive filter means responds to provide the filter means required to filter out the interference signal.

When the measurement function is digital A/D-converters 12 are also required. The means for analysing

the received signal 10 realizing the measurement function also receives information about the automatic gain control of the receiver, or the so called AGC information. This may be used to indicate that the receiver operates at sensitivity level.

Measurement of the interference spectrum in the means for analysing the received signal 10 can be realized by either digital signal processing or by narrow band analog filters (e.g. two filters). The narrow band analog filters can be combined with the actual integrated selectivity filter. The output of these narrow band analog filters together with carrier power information may be used to detect co-channel interference and adjacent channel interference conditions.

The adaptive filter means 11 can be a filter realized by digital signal processing (DSP) and controllable to a large degree, or a controlled analog filter. The filter may also be a filter selected among fixed parallel filters and suited for each of the set of predetermined interference types, as illustrated in Figures 1 to 3.

The performance of the receiver is greatly improved with the invention, and the advantage is particularly great considering the adjacent channel interference and in situations at the sensitivity level. The selectivity of the rf-parts can be decreased and tolerances increased, and the receiver noise performance could be decreased. This means cost savings and a lower current consumption.

In view of the foregoing it will be clear to a person skilled in the art that modifications may be incorporated without departing from the scope of the present invention.

## Claims

1. An adjustable filter means for selectively attenuating an interference signal, said interference signal being part of a received signal in a cellular radio telephone, the adjustable filter means comprising;

means for analysing the received signal to determine the type of interference signal present therein from a predetermined set of interference signal types;

means for generating a control signal indicative of one of said predetermined set of interference signal types so determined; and

means for applying the received signal and the control signal to adaptive filter means the frequency response of which is variable in response to said control signal to attenuate the interference signal.

2. An adjustable filter means as claimed in claim 1, wherein the adaptive filter means comprises a plu-

ality of filter means each one of which corresponds to one of said predetermined set of interference signal types.

3. An adjustable filter means as claimed in claim 1 wherein the adaptive filter means comprises a digital signal processor which controls a variable filter means.
4. An adjustable filter means as claimed in claim 1, wherein the adaptive filter means comprises a controlled variable analog filter.
5. An adjustable filter means as claimed in any of the previous claims, wherein the means for analysing the received signal comprises a digital signal processor.
6. An adjustable filter means as claimed in any of claims 1 to 4, wherein the means for analysing the received signal comprises two narrow band analog filters.
7. An adjustable filter means as claimed in any of the previous claims, wherein one of the predetermined set of interference signal types is white gaussian noise.
8. An adjustable filter means as claimed in any of the previous claims, wherein one of the predetermined set of interference signal types is co-channel interference.
9. An adjustable filter means as claimed in any of the previous claims, wherein one of the predetermined set of interference signal types is adjacent channel interference.

## Patentansprüche

1. Regelbares Filter zur selektiven Dämpfung eines Interferenzsignals, das Teil eines in einem zellularen Funktelefon empfangenen Signals ist, mit:

Mitteln zur Analyse des empfangenen Signals, um den Typ des darin enthaltenen Interferenzsignals aus einem vorbestimmten Satz von Interferenzsignaltypen zu bestimmen;

Mitteln zur Erzeugung eines Steuersignals, welches Rückschlüsse auf den einen so bestimmten Typ des vorbestimmten Satzes von Interferenzsignaltypen zuläßt; und

Mitteln zur Weitergabe des empfangenen Signals und des Steuersignals an adaptive Filtermittel, deren Frequenzantwort in Antwort auf

das Steuersignal variabel ist, um das Interferenzsignal zu dämpfen.

2. Regelbares Filter nach Anspruch 1, bei dem die adaptiven Filtermittel eine Mehrzahl von Filtermitteln enthalten, von denen jedes mit einem Typ des vorbestimmten Satzes von Interferenzsignaltypen korrespondiert. 5
3. Regelbares Filter nach Anspruch 1, bei dem die adaptiven Filtermittel einen digitalen Signalprozessor enthalten, der variable Filtermittel steuert. 10
4. Regelbares Filter nach Anspruch 1, bei dem die adaptiven Filtermittel ein gesteuertes variables analoges Filter enthalten. 15
5. Regelbares Filter nach irgendeinem der vorangehenden Ansprüche, bei dem die Mittel zur Analyse des empfangenen Signals einen digitalen Signalprozessor enthalten. 20
6. Regelbares Filter nach irgendeinem der Ansprüche 1 -4, bei dem die Mittel zur Analyse des empfangenen Signals zwei Schmalband-Analog-Filter enthalten. 25
7. Regelbares Filter nach irgendeinem der vorangehenden Ansprüche, bei dem ein Typ des vorbestimmten Satzes von Interferenzsignaltypen weißes Gaußsches Rauschen ist. 30
8. Regelbares Filter nach irgendeinem der vorangehenden Ansprüche, bei dem ein Typ des vorbestimmten Satzes von Interferenzsignaltypen eine Gleichkanalstörung ist. 35
9. Regelbares Filter nach irgendeinem der vorangehenden Ansprüche, bei dem ein Typ des vorbestimmten Satzes von Interferenzsignaltypen eine Nachbarkanalstörung ist. 40

#### Revendications

1. Un moyen de filtre réglable pour atténuer sélectivement un signal d'interférence, ledit signal d'interférence étant une partie d'un signal reçu dans un téléphone radio cellulaire, le moyen de filtre réglable comportant; 45

un moyen pour analyser le signal reçu pour déterminer le type de signal d'interférence qui y est présent à partir d'un ensemble prédéterminé de types de signaux d'interférence; 55

un moyen pour générer un signal de contrôle indicatif de l'un desdits ensembles prédétermi-

nés de types de signaux d'interférence ainsi déterminé; et

un moyen pour appliquer le signal reçu et le signal de contrôle au moyen de filtre adaptatif, dont la réponse en fréquence est variable en réponse audit signal de contrôle pour atténuer le signal d'interférence.

2. Un moyen de filtre réglable selon la revendication 1, dans lequel le moyen de filtre adaptatif comporte une pluralité de moyens de filtre, chacun d'eux correspond à l'un desdits ensembles prédéterminés de types de signaux d'interférence.
3. Un moyen de filtre réglable selon la revendication 1, dans lequel le moyen de filtre adaptatif comporte un processeur de signal numérique qui contrôle un moyen de filtre variable.
4. Un moyen de filtre réglable selon la revendication 1, dans lequel le moyen de filtre adaptatif comporte un filtre analogique variable contrôlé.
5. Un moyen de filtre réglable selon l'une quelconque des revendications précédentes, dans lequel le moyen pour analyser le signal reçu comporte un processeur de signal numérique.
6. Un moyen de filtre réglable selon l'une quelconque des revendications 1 à 4, dans lequel le moyen pour analyser le signal reçu comporte deux filtres analogiques de bande étroite.
7. Un moyen de filtre réglable selon l'une quelconque des revendications précédentes, dans lequel l'un des ensembles prédéterminés de types de signaux d'interférence est un bruit blanc gaussien.
8. Un moyen de filtre réglable selon l'une quelconque des revendications précédentes, dans lequel l'un des ensembles prédéterminés de types de signaux d'interférence est une interférence de canal commun.
9. Un moyen de filtre réglable selon l'une quelconque des revendications précédentes, dans lequel l'un des ensembles prédéterminés de types de signaux d'interférence est une interférence de canal adjacent.

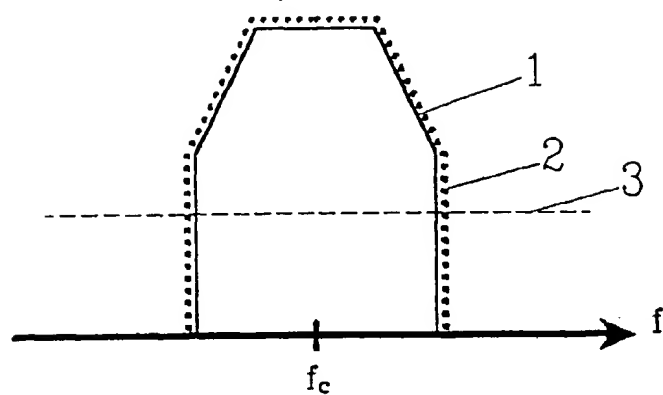


FIG. 1

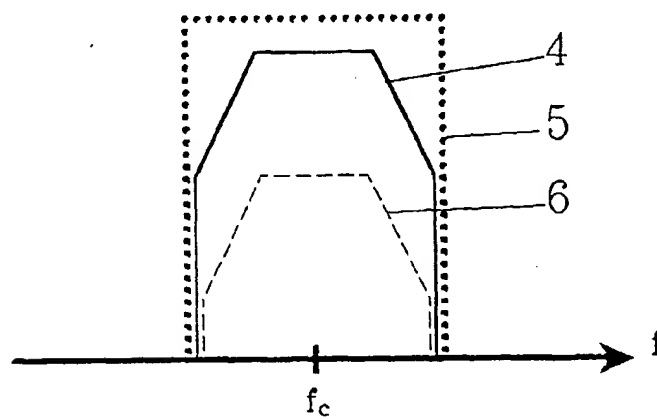


FIG. 2

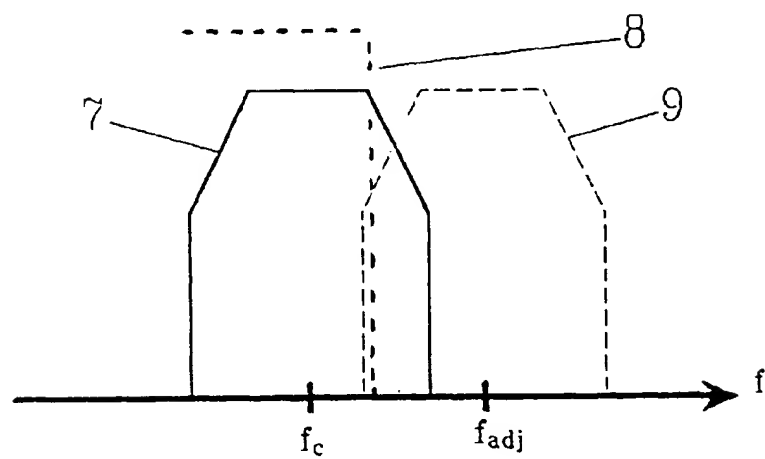


FIG. 3

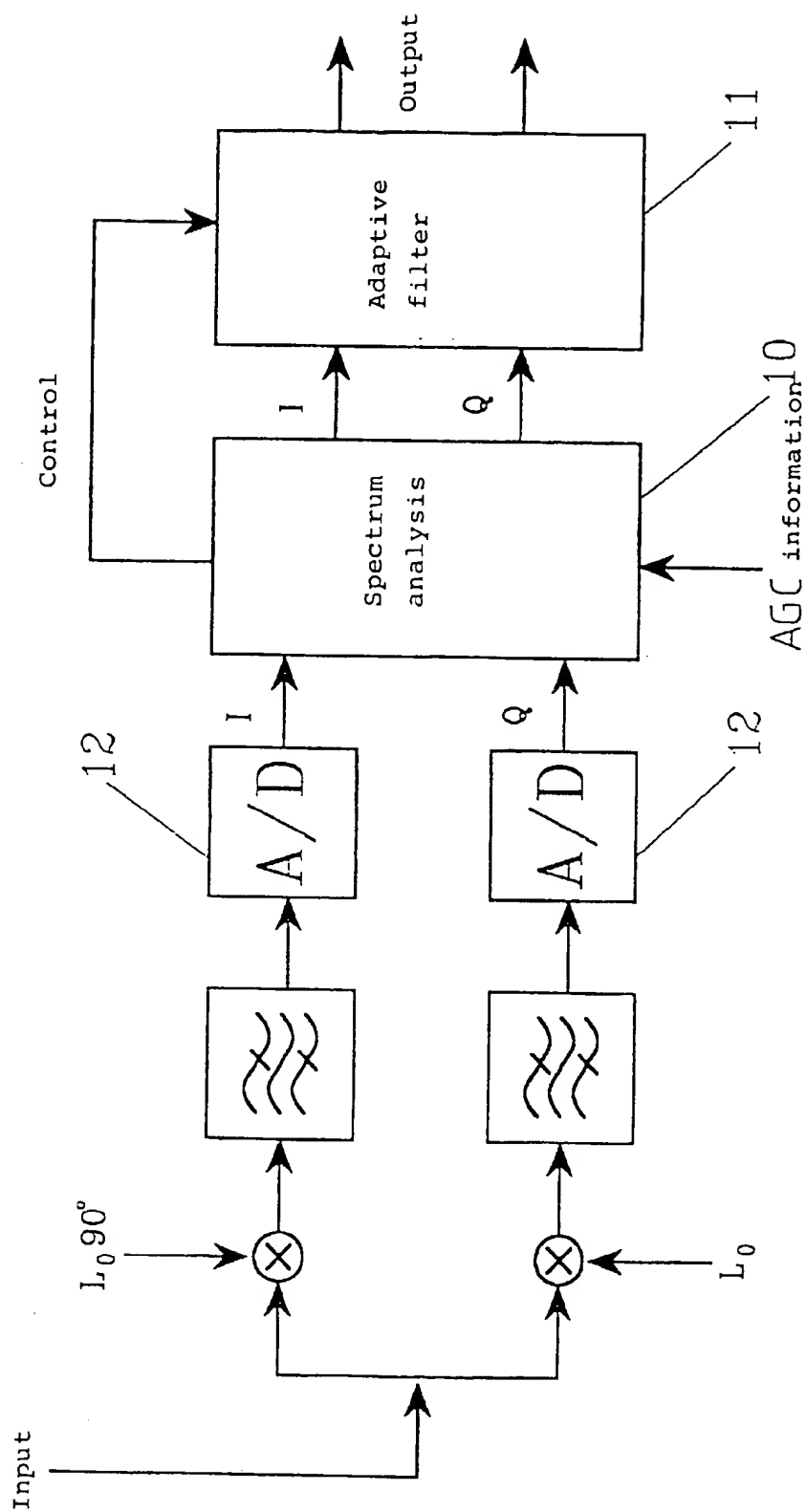


FIG. 4